A water quality indicator

Summary

It is simple and straightforward to construct a visual demonstration of how conductive water solutions are by passing a low voltage through the water with iron electrodes for 10 minutes. The Amway water treatment filter removes impurities, and hence reduces the conductivity. This in turn reduces the extent of the colour change.

Project background

James Duncan observed a video clip in Hamilton in 2004. This video clip was constructed for us as promotional material by a water bottling company. This video showed electrodes being placed into a various different waters, they all looked clear, clean and healthly. After some vigorous bubbling, and a time lapse most waters had varying amounts of black material in their water, however the company that made the video has very little material. James stated this would be great tool to help market water treatment systems. Therefore this report seeks to investigate the possibility.

Theory

There is no readily available information that explains either how the above-observed system worked, or instructions on how to build one. However research has uncovered the most likely theoretical rational.

When the electrodes are inserted into the water and connected up to a battery, or other suitable voltage source a current, will flow and one electrode becomes positive, and the other negative. These are discussed below:

- Positive electrode. This attracts negative molecules in the solution. The negative molecules in solution include oxygen, so oxygen gas will appear on this electrode. This will also include metal oxide, like copper oxide and iron oxide from water pipes. Other negative molecules will include nitrates (from organic matter), and carbonates (found in limestone areas)
- Negative electrode. This attracts positive molecules in the solution. This positive molecules in solution include hydrogen, so hydrogen gas will appear on this electrode. As water is H_20. There will be twice as much hydrogen as there was oxygen on the positive electrode. This electrode also attracts the metal ions in solution, as they are positive. Therefore metal ions such as iron, lead, arsenic, calcium will be attracted.

I hypothesize that the colour change occurs as the oxygen attracted to the positive electrode reacts with the electrode. The amount of oxygen will be proportional to how easily the current can flow through the water; this is called the conductivity of the water. The conductivity relates to how many impurities are in the water as totally pure water has a very small conductivity level. So in in essence this is system that visually indicates how conductive the water is

If these above two points are correct, we would expect to see electrodes that react with oxygen creating more visual colour change, and more conductive (i.e. not as pure water) water creating more colour change, this is what is observed below.

Experimental setup

The experimental setup consisted of a switch mode 24-volt (nominal) DC power supply with a maximum current rating of 1A (the actual current passed through the circuit was not measured). These power supplies should be available from all good electronics stores e.g. Dick Smith Electronics or Jaycar for approximately $30 The output of this was connected to electrodes. These electrodes were round bits of metal of approximately 2mm in diameter. These electrodes were then inserted into a test tube or 10mm internal diameter, holding 11ml of water.

Results and discussion

Effect of electrode

Three different types of electrodes were trialed to see if electrode composition had a significant effect. And if there was an electrode effect, what was the best substance to use.

Photographs of the copper, brass and iron electrodes are shown in Figure 1 and the results for the electrodes are shown in Figure 2.

Figure 1: Electrodes used in experiment, copper left (wiring), brass middle (rod and bolt) and iron right, (threaded rod and screw). Approximate diameter of electrodes 2mm.

Figure 2: Results for tap water, 10 minutes, 24volts DC for three different electrodes Copper (left), Brass (middle), Iron (right) . Diameter of test tubes are 10mm.

It is clear the brass electrode gives lowest total solids, copper the middle amount and iron the most significant amount. Therefore it would seem logical to use the iron electrode.

Effect of water quality

Different water was also trialed. Fish tank water that should be high in nitrates, tap water and filtered water was also trialed. The fish tank water should be higher in impurities than the tap water, and one would hope that the filtered water would also be better. The tap water was from the Waikato River water, which had been treated through the micipianl water treatment system.

Now before the experiment all water samples looked the same clear, pure looking water. There was not turbidity, nor any discoloration in any of the water samples. The test results are shown in the following figures.

The first observation is that the fish water is extremely discoloured. It is very difficult to believe that this was clear and visually no different to the other samples at the start of the process. The tap water has significant amount of rusty looking brown fluid and particulate mater. The filtered water also has particulate matter, however it is a lot less. It is also a different colour, being greener than the black of the non filtered system. Upon standing the filtered particulate mater did not compress into a solid black lump like the tap or fish tank water.

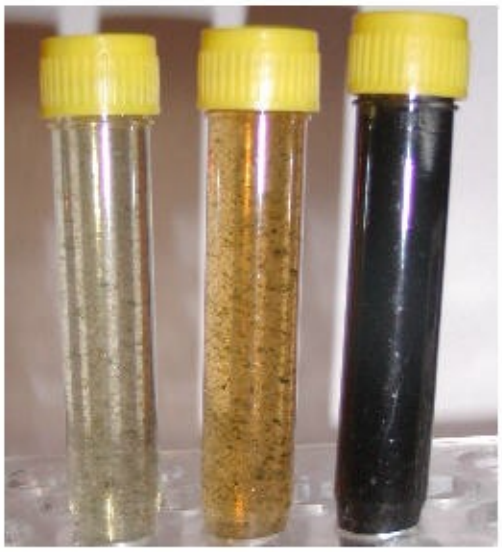

Figure 3: Filtered (left) tap (middle) and fish tank (right) test tubes inverted before photo.

Figure 4: Filtered (left) tap (middle) and fish tank (right) test tubes inverted before photo. This time against a white background, showing all discoloration

Figure 5: Filtered (left) tap (middle) and fish tank (right).
Results after settling (vertical) for about 10 mins

Improvements

Flat bottom test tubes. There are flat bottom test tubes available. This would enable then to stand without a complex holder.

Optimized time. This would enable the best result comparing filtered and unfiltered water. It would be exceptionally difficult to remove all conductive materials from water (ultra pure water does not conduct electricity)

AC supply. In retrospect experiment should have be undertaken with an AC supply. This is because only one electrode degraded by donation of iron atoms in the experiment. Visual inspection showed no discernable difference between the electrodes, however if they were to be used long term, one electrode would be eaten away, and the other remaining constant. However an AC supply switches the positive and negative electrodes at 50 times a second so that both electrodes would degrade as the same rate.

Safety notes.

As we are dealing with main supply voltage, power supplies, water and people untrained (assuming that this is used by IBO's) in electrical safely it is essential that a few safely precautions be taken.

- **RCD (Residual Charge Device).** This is a device that pugs into the wall socket before anything else. If it detects any current on the earth system it turns off. Thus if any water is splashed onto the transformer it should cut out, before anybody gets electrocuted. They are available from any hardware store and should cost between $30 and $50. They should be "tested" before each use (Simple and easy to do, just follow instructions with them)
- **Fused or temperature cut out power supply.** It is foreseeable that in the experiment that the electrodes touch together. This would create a short, and cause the maximum allowable current to be drawn from the supply. If this occurred for a minute or two and power supply is un-fused or has not temperature cut out this would most likely lead to the power supply catching on fire. Most power supplies should have a thermal cut off, so if the temperature rises above a particular point it turns off, or they are fused, however this should be checked

